Radiation Protection in Operating Theatres

Mobile C-arms are often used during procedures in operating theatres, medical departments and policlinics. Some of the procedures can involve long fluoroscopy times and relative high patient doses. Modern C-arms have normally different options for dose reduction, i.e. pulsed fluoroscopy, but also have options for high dose fluoroscopy when high image quality is needed.

Quality assurance and competence
As a part of a quality assurance system it should be ensured that the procedures include:

- Clear operational guidelines for responsibility in relation to radiation protection and the use of X-ray equipment. This comprises both system responsibility, and, responsibility in the particular department.
- Protocols to ensure that the operators of the equipment have the necessary knowledge of radiation protection and training in the use of the equipment. Especially important are knowledge of factors that influence image quality and radiation dose.
- Protocols for education and training for all personnel that are involved in the procedures. Education and training should be given after installation of new equipment and be re-peated on a regularly basis.
- Protocols that ensure that the equipment is maintained and properly adjusted.

Equipment
The C-arm has an image intensifier and an x-ray tube positioned directly opposite from each other, and the C-arm is capable of many different movements.

The control panels on older equipment often have modes for fluoroscopy with au-tomatic brightness control (ABC), mode for manual control of the kV and current (mA), and sometimes possibilities for radiographs with a cassette.

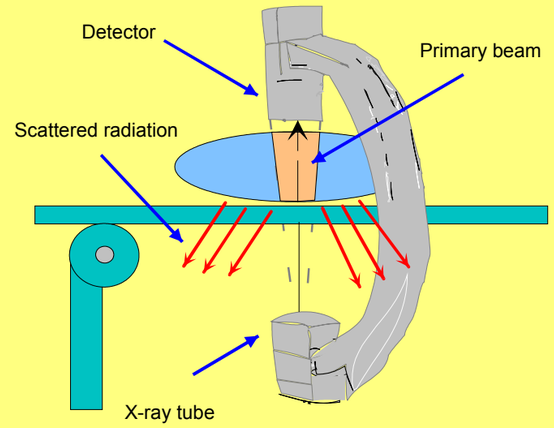
Modern C-arms can in addition have options for pulsed fluoroscopy, different options for dose rates and image quality, magnification, digital subtraction and other alternatives.

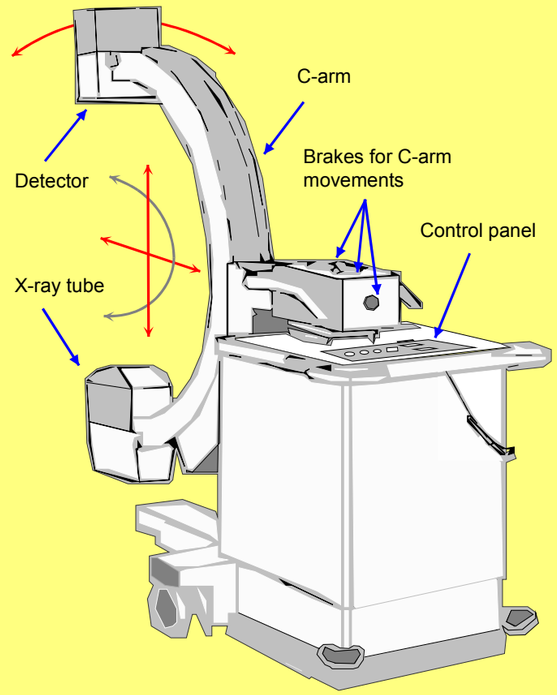
Controlling the dose
The adjustment of the fluoroscopy parameters (kVp and mA) are usually done by an au-tomatic system that regulates the entrance skin dose rate to the patient to give a constant dose to the detector. The entrance skin dose rate to the patient will hence vary between dif-ferent patient thicknesses and densities in order to get a constant dose to the detector.

Pulsed fluoroscopy means that the radiation is switched on and off in short intervals during the exposure, which results in a decreased dose to patient and personnel. However pulsed fluoroscopy can be perceived as jerky when dynamic processes are monitored.

Magnification means that an area is magnified on the monitor. This could be done by zooming on the monitor or by magnification on the detector. Zooming on the monitor doesn't give any change in the dose. When using an image intensifier system, the skin dose to the patient often will increase when magnification is used. A general rule is that when the image quality is increased, the skin dose to the patient will also increase, and also result in more scattered radiation to personnel.

Important take home messages · *Use the automatic dose control · Make use of pulsed fluor-oscopy if it is practically achievable · Increased image quality can generally only be achieved by increasing the radiation dose · A decrease in the patient exposure will also give a benefit in terms of decreased staff doses.*





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Primary radiation field
Avoid the primary radiation field. The intensity is 100-1000 higher than just outside the field.

Scattered radiation
When exposing a patient scattered radiation will be created, which means that the main source for dose to the staff is the patient.

The main part of the scatter will be scattered towards the x-ray tube (see figure). The most favourable position of the x-ray tube during fluoroscopy is hence under the patient and the detector as close as possible to the patient.

Collimation of the radiation field is also an effective method to reduce the scattered radiation. The image quality will also increase, because less scattered radiation will hit the detector which results in loss of contrast. Collimation of the radiation field can often be done without using fluoroscopy.

Screening time
Don't use more fluoroscopy then necessary. For an orientation it's often sufficient to use the last-image-hold. Last-image-hold is also often sufficient as documentation for the procedure.

Distance
Scattered radiation is inversely proportional to the square of the distance from the source. This means that if the distance to the radiation source (the patient) is doubled, the radiation will be reduced to a ¼. This will have impact for both patient and staff doses. Short source to skin distance can result in high skin doses. Especially care should be taken when angled projections are used. For staff will an increase in distance be especially important when standing close to the patient. A step backwards can have significant impact. When standing more far away from the patient, a step away or towards the patient will have less impact.

Shielding
All involved staff during a procedure should use lead aprons. The lead apron should be suited for the actual tasks the individual staff have during the procedure. Physicians standing static near the patient during the procedure can often have an apron covering the front and reaching to the knees. Scrub nurses i.e., which often are moving around during the proce-dures, should have aprons covering both the front and the back. When using long fluoros-copy times and over-couch tube, thyroid shielding should be considered for those standing near the patient.

Remember: *Collimation – Time – Distance*

- Provide necessary education and training in radiation protection and use of X-ray equipment.
- Avoid the primary beam
- Smallest possible radiation field. Collimate around area of interest.
- Shortest possible fluoroscopy time
- X-ray tube under the patient
- Detector as close as possible to the patient
- Use lead apron. It reduces the radiation dose to about 10%
- Shortest time as possible near the patient
- Keep distance